15 Technologies for agricultural transformation

Animal health

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Introduction

Animals in Southern Africa are essential for nutrition, income, livelihoods and ecosystem services. However, animal diseases are a threat both to the performance of the livestock sector and to the ability of countries to benefit from wildlife resources. Animal diseases can also have direct and indirect impacts on human health. In this chapter we first summarize the different categories of animal disease and their relevance to Southern Africa. Next, we review the technologies that are presently available, and which are being taken up, or could be taken up, by livestock keepers. We then discuss the approaches that can help close the gap between technologies and widespread adoption. Finally, we make recommendations for research and policy to overcome these barriers.

Priority animal diseases in Southern Africa

As is the case in many low- and middle-income countries (LMIC), information on the burden of animal disease in Southern Africa is lacking. Here we draw on a survey of state veterinary services (Grace et al., 2015a), the information officially reported to the World Animal Health Organisation (www.whahid.org) and the literature (Grace et al., 2012; World Bank, 2012) to identify the priority diseases under different categories.

- Epidemics are defined as occurrence of a certain disease in a population at levels higher than expected. The most important livestock epidemic diseases are caused by rapidly transmitting pathogens that produce acute and serious disease in large numbers of hosts. According to state veterinary services, the priority epidemic disease in Southern Africa is foot and mouth disease (FMD) followed by contagious bovine pleuropneumonia (CBPP). Other priority epidemics are *peste des petits ruminants* (PPR), Newcastle disease and lumpy skin disease (LSD).
- Endemic diseases are constantly present in a population. Although livestock endemic diseases are less dramatic than epidemics, some believe that the overall impact is greater. Even though a disease is endemic in an area,

seasonal or sporadic outbreaks may occur. Endemic diseases important in Southern Africa are clostridial diseases, ticks and tick-borne diseases (TTBD), helminth infections and African animal trypanosomosis (AAT).

- Zoonoses are animal diseases that are transmissible to people. Over 60% of human pathogens are zoonotic (Taylor et al., 2001), but a smaller number of zoonoses are responsible for most illness. The priority zoonoses in Southern Africa are rabies, followed by brucellosis and anthrax. Other zoonoses are emerging. For these diseases, human infection is currently rare, but as these pathogens evolve they may become better adapted to humans: priority emerging diseases are highly pathogenic avian influenza (HPAI) and Rift Valley fever (RVF).
- More than half of the priority foodborne diseases are zoonotic (Havelaar et al., 2015), and animal source foods are an important source of both zoonotic and foodborne diseases. The human health impact of foodborne disease is comparable to that of HIV/AIDs, malaria or tuberculosis (Havelaar et al., 2015). The economic costs for LMICs are at least US$115 billion a year (Jaffee et al., 2018). Foodborne disease is likely to worsen in Southern Africa over the next decades (Grace, 2015).
- The priority wildlife diseases are FMD and anthrax, which are also diseases of livestock and the priority aquatic diseases is epizootic ulcerative syndrome.

The distribution of infectious diseases (human, animal and plant) and the timing and intensity of disease outbreaks is often closely linked to climate and weather. Associations are strongest for diseases that are vector-borne, soil associated, water or flood associated, rodent associated or air temperature/humidity associated, and most of the priority animal diseases in Southern Africa are considered climate-sensitive (Grace et al., 2015b).

Technologies for better managing animal disease

Technological advances have revolutionized our ability to detect, diagnose, cure and prevent animal diseases.

Diagnostics are used to understand infection and epidemiology, in monitoring disease, in discovering pathogens, in developing and evaluating control strategies and in treating individual animals. Advances in diagnostics include the use of recombinant technology, the development of lateral flow tests and real-time polymerase chain reaction (PCR) on field lab platforms (Howson et al., 2017). However, many of these tests are not yet routinely used or commercially available. Their introduction will depend upon investment in the technology, leading to performance and cost advantages over the existing approaches used to control disease outbreaks which in turn depends upon developing a commercial market.

In tropical developing countries, there is also a need for field-friendly diagnostic tests. A good example of this is the FAMACHA test for anaemia in sheep

to detect animals who need treatment for haemonchosis. Animals are restrained, and the eyes are examined and scored against a standardized set of five colours ranging from red-pink (normal) to white (terminal anaemia). Developed for use in sheep in South Africa, the method has been extended to other animal systems and used in other countries (O'Brien et al., 2018).

Vaccines are one of the most effective means of controlling disease, and there are more than 300 veterinary vaccines registered around the world (Barrett, 2016). Although vaccines exist for many priority diseases, technological advances can improve uptake and usability. Thermostable vaccines exist for Newcastle disease and are under development for other diseases. "DIVA" (differentiation of vaccinated from naturally infected animals) vaccines allow vaccinated and infected animals to be distinguished so the latter can be culled. Molecular epidemiology allows the development of vaccines that are safer and cheaper and give long-lasting immunity. Insertion of protective antigens into a live but apathogenic vector organism (vector-based vaccines) has been used successfully against viral diseases but are still only emerging for bacterial diseases. Multivalent vaccines can protect against several diseases and are attractive to farmers.

There is also a rapidly growing concern about increasing antimicrobial resistance in human pathogens. One landmark study predicted that by 2050, 10 million deaths worldwide will be attributable to antimicrobial resistance (O'Neill, 2016). The use of antimicrobials in agriculture is considered to contribute to this, and there is much interest in innovations that would allow reduction of antimicrobials in livestock. As well as vaccines, research in Africa is investigating the potential of prebiotics, probiotics, phages, heavy metals, phytochemicals, organic acids, engineered peptides, nanoantibiotics, highly effective chicken and plant immunoglobulins and genetically resistant animals (Marquardt and Li, 2018).

Information and communication technologies (ICT) and eAgriculture has been one of the fastest growing areas in recent years and has many applications to animal health (also see Chapter 4.4 in this volume). Several projects in Africa have used mobile telephones to send information to producers and to support disease reporting. Use of electronic tags and readers can transform paper-based livestock traceability systems into an ICT-compliant system that is more secure and transparent. Model systems have been used in South Africa and Namibia and are considered to have wide applicability (Gitonga, 2017). Blockchain also has potential to revolutionize livestock value chains.

Accurate information on presence, level and impacts and the costs for controlling disease is needed to plan disease control. Disease surveillance is an information-based activity that involves collection and analysis of information on disease occurrence. Well-functioning surveillance systems and timely responses may reduce the cost of outbreaks by 95% (Grace, 2014). Most developing countries currently lack capacity to detect diseases. Promising surveillance and reporting opportunities for poor countries include:

- Risk based (targeted) surveillance: traditional surveillance assumes that the probability of disease is constant across all individuals, but this is rarely the

case. By concentrating surveillance on the diseases, sectors, sub-populations or areas most likely to be affected, costs can be reduced and efficiency increased.

- mSurveillance: mobile phones have reached widespread cover in developing countries. Pilot programmes involving veterinarians, community animal health workers and farmers have been successful in several countries.
- Participatory disease surveillance (PDS) was originally developed in Africa to harness the skills of local communities in detection and reporting of rinderpest. It has subsequently been used for several diseases including avian influenza. It often reaches further and costs less than traditional surveillance. However, reports typically require confirmation by other means.
- Satellite data are increasingly being used to aid disease prediction, especially for those diseases that occur in epidemics such as Rift Valley fever. There is huge potential to calibrate these data, based on the local Meteorology Station data, so they can be used in short-term disease prediction and longer-term forecasting. These can be combined with mathematical models to better understand options for disease control.

Translating technologies to better animal health

Technologies by themselves will not improve animal health. Mechanisms are needed by which they can be deployed at scale. Recent years have seen the development of a series of approaches that bring together processes, technologies with enabling policies and incentives to bridge the gap between innovation and adoption. Three key approaches are sustainable intensification, progressive disease control and risk-based approaches for food safety.

Sustainable intensification implies increasing livestock productivity but not at the expense of the environment, or economic or social well-being. Countries in Southern Africa, like many LMIC, are forecast to experience significant growth in demand for livestock and fish products over the next decades. At the same time, there is increasing concern over the environmental externalities of livestock especially their contribution to greenhouse gas, pollution and environmental degradation. In Southern Africa, much of the livestock is kept by smallholders or by farmers who keep large numbers of animals but operate low-input, low-output systems. For these farmers, intensifying farming – as opposed to industrializing it – can be supported by adoption of a package of technologies. These include enhancing feed, better matching genetics with environment and improving health (ILRI, 2019). Producing more from less can also reduce the per kilogram carbon footprint of livestock products.

Progressive disease control, with the ultimate aim of eradication, has become prioritized as a result of the successful eradication of rinderpest or cattle plague. This catastrophic disease of ruminants was the second disease to be eradicated from the planet (after smallpox).

Eradication led to nearly a billion dollars in annual economic benefits in Africa alone, bringing immense benefits to livestock keepers. Global eradication may not always be feasible, but many diseases can be controlled by a

combination of treatment, vaccination, culling and reduction of transmission. Control is usually staged with initial measures used to reduce prevalence progressing to more rigorous and expensive methods to eliminate infection. These staged approaches bring together stakeholders to develop a road map for control. They have been developed for foot and mouth disease (OIE and FAO, 2012), trypanosomosis (Diall et al., 2017), cysticercosis and other priority diseases present in Southern Africa. Control activities are most advanced for peste des petits ruminants (PPR) and rabies (Jarvis, 2016). PPR eradication is expected to cost US$2.26 billion over 15 years, which will create US$76.5 billion in benefits to farm communities, nearly 34 times the original investment and equal to 25% of the annual agricultural output of sub-Saharan Africa (Jones et al., 2016).

South Africa experienced the world's largest ever recorded outbreak of listeria (Listeria monocytogenes), with 209 human deaths between January 1, 2017, and June 5, 2018. Domestically processed ready-to-eat meat was identified as the probable source (Hunter-Adams et al., 2018). Managing food safety is best done through use of risk analysis: this combines risk assessment (what is the risk to human health?), risk management (what best to do about it?) and risk communication (the two way and iterative engagement among stakeholders). Although the gold standard for managing food safety, risk analysis has not been widely adopted in LMICs. In the last decade, participatory methods have been developed to make risk analysis easier to apply and have been successfully used in several countries in Southern Africa including Tanzania, Mozambique and South Africa (Roesel and Grace, 2014).

Policy and processes to improve animal health in Southern Africa

The increasing importance of the human health externalities of agriculture, including emerging diseases, zoonoses and antimicrobial resistance, means animal health has to go beyond impacts on livestock and fish. The best practice for managing these is an approach known as "One Health" or Ecohealth. This assumes that the health of humans, animals and the planet are interdependent and problems at the intersection of human and health require solutions based on cross-disciplinary collaborations. Community animal health programmes have been successfully implemented in many countries but require an enabling national animal health policy, which is not always present. Governments can establish and support cross-ministerial One Health units, apply One Health methods to the control of zoonotic diseases and AMR and support community-based animal health services (Munyua et al., 2016).

Societies around the world increasingly recognize the obligation to treat animals humanely. Animal welfare fits naturally into health discussions: poor animal health causes great animal suffering, and reduction in animal disease also reduces disease in humans. In addition, animal welfare is related more broadly to livestock production. Providing adequate nutrition, husbandry and housing

for livestock is critical for their welfare as well as for their productivity. Adequate livestock transport and competent slaughter processes reduce both animal suffering and losses from damaged carcasses. In developing and emerging economies, improvements in livestock welfare often simultaneously improve livestock productivity, presenting a win-win opportunity. Governments need to ensure animal welfare legislation is present and raise awareness on the need for, and benefits of, improving animal welfare,

Veterinary Services (VS) comprise all actors, public and private, who collaborate in the domain of animal health under the overall control and direction of the Chief Veterinary Officer. Veterinary services are a global public good and are essential to safeguarding and improving the health of animals and animal-related health and nutrition of people. They are essential to global trade in livestock and livestock products. There is considerable evidence that these services have been underinvested in (OIE, 2019) and that adequate funding of VS has considerable benefits for animal and human health (Jaffee et al., 2018). The Performance of Veterinary Service Pathways supported by the OIE offers an appropriate and sustainable way for Southern African countries to strengthen VS (see www.oie.int/solidarity/pvs-evaluations/).

Conclusions

We are currently in an era of unprecedented interest and advances in animal disease research. This livestock sector is growing rapidly in response to demand, and the consequent intensification brings about needs for new and adapted technologies. Advances in epidemiology, molecular epidemiology, genomics, diagnostics, vaccines and ICT have great potential for controlling disease and improving productivity in livestock. At the same time, the growing concern about human health externalities of livestock production (especially emerging zoonotic disease, foodborne disease and antimicrobial resistance), substandard animal welfare and the environmental impact of livestock is stimulating new investments in research to tackle these problems. Much of the growth in demand for livestock products and generation of negative externalities occurs in LMIC, and these will be at the forefront of future research. A One Health perspective that understands the importance of livestock in the context of animal, human and environmental health can help ensure a sustainable transformation of the livestock sector.

References

Barrett, A. (2016) 'Vaccinology in the twenty-first century', *NPJ Vaccines*, p. 1.

Diall, O., Cecchi, G., Wanda, G. et al. (2017) 'Developing a progressive control pathway for African animal trypanosomosis', *Trends in Parasitology*, vol 33, no 7, pp. 499–509.

Gitonga, P. (2017) 'Livestock management, identification and traceability solution', unpublished, https://doi.org/10.13140/rg.2.2.28790.19523.

Grace, D. (2014) 'The business case for one health', *The Onderstepoort Journal of Veterinary Research*, vol 81, p. 2.

Grace, D. (2015) 'Food safety in low and middle income countries', *International Journal of Environmental Research and Public Health*, vol 12, no 9, pp. 10490–10507.

Grace, D., Bett, B., Lindahl, J. et al. (2015b) 'Climate and livestock disease: Assessing the vulnerability of agricultural systems to livestock pests under climate change scenarios', CCAFS Working Paper no. 116., *CGIAR Research Program on Climate Change*, Agriculture and Food Security, Copenhagen.

Grace, D., Mutua, F., Ochungo, P. et al. (2012) *Mapping of poverty and likely zoonoses hotspots*, International Livestock Research Institute, Nairobi.

Grace, D., Songe, M. and Knight-Jones, T. (2015a) 'Impact of neglected diseases on animal productivity and public health in Africa', paper written for 21st conference of the *World Organisation for Animal Health (OIE) Regional Commission for Africa, Rabat, Morocco, 16–20 February*, International Livestock Research Institute, Nairobi.

Havelaar, A.H., Kirk, M.D., Torgerson, P.R. et al. (2015) 'World health organization global estimates and regional comparisons of the burden of foodborne disease in 2010', edited by von Seidlein, L., *PLOS Medicine, Public Library of Science (PLoS)*, vol 12, no 12, p. e1001923.

Howson, E., Soldan, A., Webster, K. et al. (2017) 'Technological advances in veterinary diagnostics: Opportunities to deploy rapid decentralised tests to detect pathogens affecting livestock', *Revue Scientifique et Technique de l'OIE*, vol 36, no 2, pp. 479–498.

Hunter-Adams, J., Battersby, J. and Oni, T. (2018) 'Fault lines in food system governance exposed: Reflections from the listeria outbreak in South Africa', *Cities & Health*, vol 2, pp. 17–21.

ILRI. (2019) *Options for the livestock sector in developing and emerging economies to 2030 and beyond*, Meat: The Future – Economic Forum, Geneva.

Jaffee, S., Henson, S., Unnevehr, L. et al. (2018) *The safe food imperative: Accelerating progress in low- and middle-income countries*, Agriculture and Food Series, World Bank, Washington.

Jarvis, S. (2016) 'Aiming for elimination of dog-mediated human rabies cases by 2030', *Veterinary Record, BMJ*, vol 178, no 4, pp. 86–87.

Jones, B.A., Rich, K.M., Mariner, J.C. et al. (2016) 'The economic impact of eradicating peste des petits ruminants: A benefit-cost analysis', edited by Chakravortty, D., *PLoS One, Public Library of Science (PLoS)*, vol 11, no 2, p. e0149982.

Marquardt, R.R. and Li, S. (2018) 'Antimicrobial resistance in livestock: Advances and alternatives to antibiotics', *Animal Frontiers*, Oxford University Press (OUP), vol 8, no 2, pp. 30–37.

Munyua, P., Bitek, A., Osoro, E., Pieracci, E.G., Muema, J., Mwatondo, A. et al. (2016) Prioritization of zoonotic diseases in Kenya, 2015. *PLoS One*, vol 11, no 8, p. e0161576.

O'Brien, D., Schoenian, S., Semler, J., Gordon, D. and Bennett, M. (2018) 'PSVI-19 Consistency of FAMACHA© scores to fecal egg counts and gain in meat goat kids', *Journal of Animal Science*, Oxford University Press (OUP), vol 96, suppl_3, pp. 460–461.

OIE. (2019) https://www.oie.int/fileadmin/Home/eng/Media_Center/docs/pdf/SG2018/PVS_BUSINESS_CASE_FINAL.pdf.

OIE and FAO. (2012) *The global foot and mouth disease control strategy*, Food and Agriculture Organisation of the United Nations, Italy and World Organisation for Animal Health, Paris.

O'Neil, J. (2016) Tackling drug-resistant infections globally: Final report and recommendations. *The Review on Antimicrobial Resistance*. https://amr-review.org/publications (accessed 2016), 84p.

Roesel, K. and Grace, D. (2014) *Food safety and informal markets: Animal products in Sub-Saharan Africa*, Routledge, Oxford.

Taylor, L.H., Latham, S.M. and Woolhouse, M.E.J. (2001) 'Risk factors for human disease emergence', edited by Woolhouse, M.E.J. and Dye, C., *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, The Royal Society, vol. 356, no 1411, pp. 983–989.

World Bank. (2012) *People, pathogens and our planet*, World Bank, Washington.